AGRICULTURAL LAND CONVERSION ON MAKASSAR VICINITY

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Abstract: Makassar city is the capital South Sulawesi province (05^0 08' S; 119^0 25' E) sited on the western coast of the province, with population around 1.4 million (2011). The city laid on the northern side (downstream) of the Jeneberang river and shares the river's floodplain with the city of Sungguminasa.

The city of Makassar is a waterfront city surrounded by fertile agricultural land (mostly the rice field and dry land agriculture) on southern, eastern and northern sides. The rising demand of residence and business are enhance the sprawling of the city front lines over the fertile and technically irrigated fields on its vicinities. The advance of urban sprawl in Makassar and Sungguminasa traced by analyzing the multi-temporal data of remotely-sensed data on three sub urban area i.e. Kecamatan Pallangga and Sombaopu on south-eastern direction (Kab. Gowa), Jeneberang delta and Kecamatan Biringkanaya on the nothern area.

The analyses shows that the sprawling of the city front lines over the last 10 to 15 years has been occurred rapidly, especially on Jeneberang delta where the farms has been converted into massive business area with the rate of conversion around 18% (8.4 ha/yr.) and 34% (30.3 ha/yr.) within the 1999 to 2003 and 2003 to 2010 respectively. The conversion rate in Kecamatan Biringkanaya during 1995 to 2003 and 2010 are 37 and 66 ha/year respectively and in Kecamatan Pallanga and Sombaopu is observed 172 ha/year from 1996 to 2010

Keywords: Agricultural land, remote sensing, conversion rate, supervised classification

INTRODUCTION

The city of Makassar, the capital of South Sulawesi sited on the western coast of the South Sulawesi peninsula with population of 1.25 million in 2009, and annual growth of 23 %. The city laid on the northern side (downstream) of the Jeneberang River and shares the river's floodplain with the city of Sungguminasa. The river's watercourse has formed a delta on the coastal zone of Makassar [1]. This city has underwent rapid expansions into surrounding vicinity especially to the southern, eastern and northern directions including the conversion of Jeneberang delta of which predominantly used as wetland and agricultural area into a massive urbanization.

In order to determine the rate of urban advancement and surrounding agricultural land conversion, remote sensing data and Geographical Information System (GIS) technology offer a sound solution. A broad view of landscapes provided by remotely-sensed data can be consistent through time, making it an important tool for monitoring and managing certain area such as protected lands[2]. Change detection on landscapes by digital images essentially comprises of quantification of temporal phenomena from multi-date imagery[3].

Land cover composition and change are important factors that affect ecosystem condition and function [4]. The advancement of the city development in water front cities usually surpasses the wetland area which playing an important role in ecological balance on either terrestrial or estuarine ecology. The concentration of people in densely populated urban areas, especially in developing countries, calls for the use of monitoring systems like remote sensing. Such systems along with spatial analysis techniques like digital image processing and geographical information system (GIS) can be used for the monitoring and planning purposes as these enable the reporting of overall sprawl at a detailed level[5].

The use of satellite-based remotely-sensed data has been extensively used to provide a cost-effective means to develop land coverage and change detection over large geographic regions [4]. In

recent years, the accessibility to remotely sensed data with little or even no-cost such as Landsat / Google Map offering an even more accurate analysis on the land use change anywhere in the world.

METHOD AND STUDY SITES

This study examines the quantitative and qualitative changes in the past 20 years related to urban sprawl over agricultural area and its impact on three different areas around Makassar city that is: the Jeneberang river delta in the southern part of Makassar city, Kecamatan Sombaopu and Pallangga (in the eastern region of Sungguminasa) and Kecamatan Biringkanaya in the north (Figure 1).

The image used in this study consisted of multi-date remote sensing imageries, mostly from Landsat 5 TM and the images extracted from Google Earth ™ over the delta of Jeneberang river. The images used in this analysis summarized in Table 1.

Table 1. The image data used in the study

Images	Jeneberang Delta		Kec. Biringkanaya		Kec. Sombaopu & Pallangga (Gowa)	
	Sat. / Image	Date	Sat.	Date	Sat.	Date
1	Landsat 7 (ETM)	13 Sept. 1999	Landsat 5 (TM)	APR. 26 1995	Landsat 7 (ETM)	May 21 1996
2	Quickbird (Google Earth)	Apr. 18 2003	Landsat 5 (TM)	Oct. 24 2003	Landsat 5 (TM)	Feb. 24 2010
3	Quickbird (Google Earth)	Jul. 13 2010	Landsat 5 (TM)	Feb. 14 2010	-	-

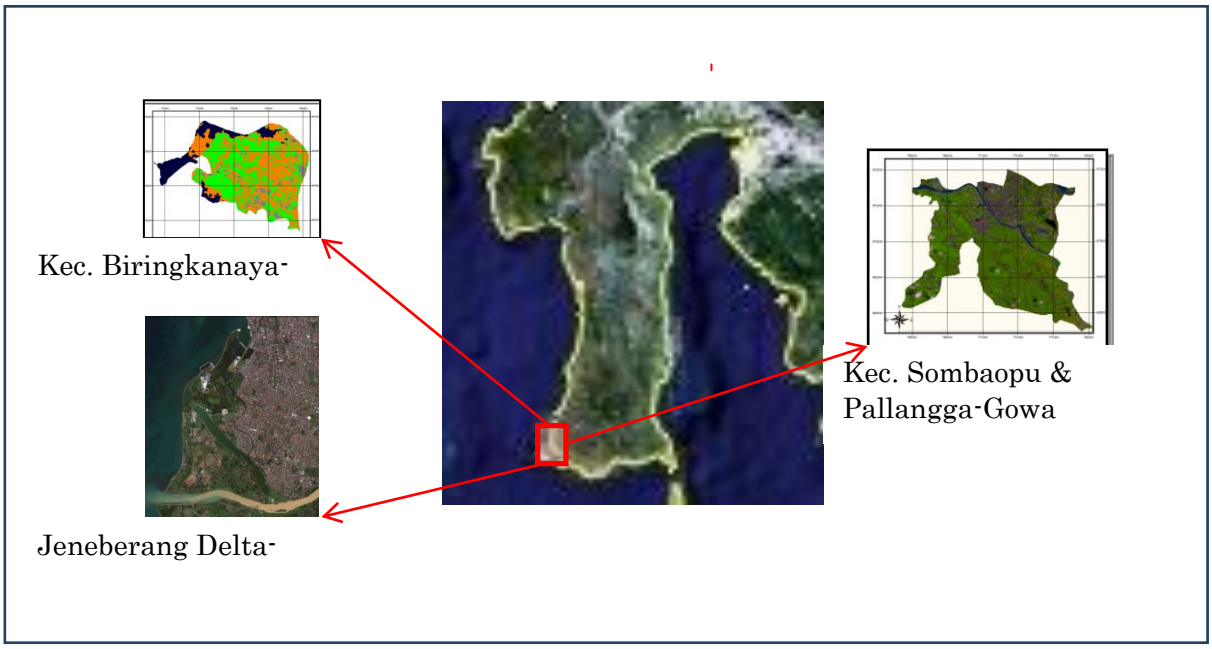

Figure 1. The Study Location

The method used in this study using a series of remotely-sensed data using Landsat TM imagery and the digital maps derived from Goggle earth. The procedure in the study consists of the pre-processing of the Landsat TM data started from image preprocessing (dark object subtraction and geometric corrections), classification and land use change mapping (Fig. 2). The image classification based on supervised classification [6, 7] is applied to the Landsat TM imagery as well as accuracy assessment [8] of Kappa coefficient.

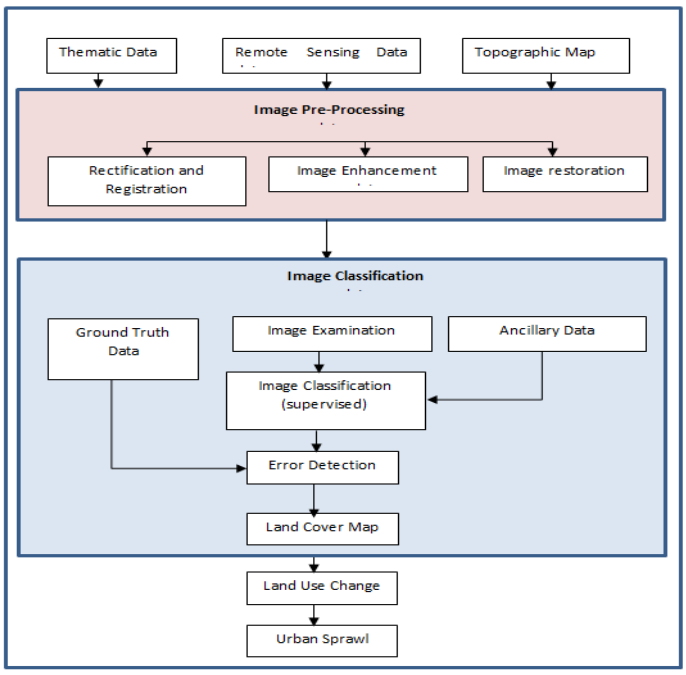

Figure 2. Flowchart of Research Procedure

Some raster and vector processing software on the image and map processing were used in this study. Training areas were selected for each of the land use types by delimiting polygons around certain types of land use i.e. rice fields, fishponds, buildup areas, mangroves and free water body. Using the pixels from training regions the classification process is started using supervised classification with maximum likelihood method as classification method. The output is a thematic raster layer (classified image). The thematic layer was used for mapping the land use of post classification map. The accuracy of the classification of remotely sensed data usually decreases as more classes are derived [9].

The classification accuracies are measured in terms of overall accuracy, producers accuracy and users accuracy and the Kappa coefficients. The user's accuracies are the measure of commission error indicates the probability that a pixel classified into a given category actually represents that category on the ground. On the other hand, the producer's accuracies reflecting the accuracy of a pixel that omitted from the category that a pixel should belong to. The Kappa statistic ("K_{Hat}"), is the measure of the difference between the actual agreement between reference data and an automated classifier and the chance agreement between the reference data and a random classifier[6]. The Kappa statistic is expressed as:

$$K_{hat} = \frac{N\sum_{i=1}^{r} xii - \sum_{i=1}^{r}(x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} * x_{+i})}$$

Where r = number of rows in the error matrix; xii = the number of observations in the row I (major diagonal); xi+ = the number of observation in row I; x+i = total observation in column and N = total number of observation.

The classification results from the three area of interests are discussed in the following sections.

REULTS AND DISCUSSIONS

Image Classification and accuracies

Classification accuracy is one of the major limitations of digital image analysis, and usually lower than expected. The accuracy of classified images varies with the detail level and the number of

ground covers mapped. The general classification accuracies hovers around 60 to 80 percent, and higher accuracy is difficult to achieve because the computer is able to take advantage of only a small portion of the information inherent in the input image, while the large portion of it is disregarded [10]. Therefore, the accuracy is rather limited for ground covers which spectral response bears a high resemblance to that of other covers.

The result of image analysis performed by supervised classification on satellite image required a validity assessment to ensure the accuracy of classification. The validity of classification result is validated using reference data or ground truth. The ground truth data obtained by visiting the specific location on the ground as well as using visual assessment on high resolution image data. The error matrices [6] of classified images of the three locations presented in Table 2, Table 3 and Table 4 respectively.

Table 2.The error matrix of Jeneberang Delta

Land use	User's Acc. (%)	Commission Err. (%)	Prod. Acc. (%)	Omission Err. (%)
Dry land and RF	96	4	83	17
Wetland	88	12	92	8
Buildup	80	20	91	9

Overall accuracy 88%Kappa coef. (K_{Hat}) 0.82

Table 3.Error Matrix of Kec. Sombaopu and Pallangga

Landuse 2010	Producer Accuracy (%)	User Accuracy (%)	Omission Err. (%)	Commission Err. (%)
Ricefield	86.79	92	13.20	8
Dryland Farm	87.75	86	12.24	14
Residential	92.30	96	7.69	4
Wetland	88.0	88	12.0	12
Water	97.82	90	2.17	10

Overall accuracy 80.4% Kappa coef. (K_{Hat}) 0.88

Table 4.Error Matrix of Kec. Biringkanaya

Landuse 2010	Producer Accuracy (%)	User Accuracy (%)	Omission Error (%)	Comission Error (%)
Ricefield	81	88	19	12
Dryland Farm	88	92	12	8
Residential	84	67	16	33
Wetland	84	89	16	11

Overall accuracy 83.6% Kappa coef. (K_{Hat}) 0.88

The overall accuracies of the three image classifications show that all of them ranged from 80.4 to 88 % and the Kappa coefficient also above 80%.

Land conversion on Jeneberang Delta.

Jeneberang delta has been transformed into a massive urban development since the access road into the delta in the late 1990s. The blockage of the right side river course enables the rapid

development in the region. The consequence is that the agricultural lands (rice fields and dry land farms) has been diminished from 38% in 1999 to 35 % in 2003 and in 2010 its only left 14% (Table 5 and Table 6), while the buildup area increase sharply from 21% in 1999 to 73% in 2010.

Table 5. Land use portions of Jeneberang Delta from 1999to 2003 and 2010

Year	1999 (ha)	%	2003 (ha)	%	2010 (ha)	%
Dryland farming and ricefield	381.19	38%	347.60	35%	135.37	14%
Wetland	406.67	41%	264.48	26%	136.20	14%
Buildup area and Residence	213.37	21%	389.16	39%	729.26	73%
Total (ha)	1001.24	100%	1001.24	100%	1001.24	100%

Table 6. Percentage of land use change in Jeneberang delta 1999-2003 and 2003-2010

Land use / Year	1999-2003	% Change	Rate (ha/yr)	2003-2010	% Change	Rate (ha/yr)
Dryland farming and ricefield	-33.59	-3%	-8.4	-212.23	-21%	-30.3
Wetland	-142.19	-14%	-35.5	-128.28	-13%	-8.3
Buildup area and Residence	175.79	18%	43.9	340.10	34%	48.6

The rate of land use change in Jeneberang delta as shows in Table 6 suggest that during 4 years period (1999 to 2003) the natural condition of wetland area in the delta declined 14% and on subsequent seven years (2003 to 2010) the area is further reduced by 13%. The similar patterns happened to the dry land farming and rice fields at the same periods where the area reduced from 38% to 14% with conversion rate of 8,4ha/yr (1999-1003) and 30.3 ha/yr (2003-2010). On the other hand, the buildup area increased significantly as Table 3 shows the rapid increase of 18% in the first period and further 34% in the last 7 years. This trend shows that one day the Jeneberang delta will be converted into a massive concrete and paving area that the wetland ecosystems and farming practice will dwindle and disappear in the coming future. The rate of urban sprawl over the farmland and wetland in this area within the first four years is 43.9 ha/yr, and on subsequent 7 years is 48.6 ha/yr.

Kecamatan Biringkanaya

The urban sprawl on agricultural land (rice fields and dry land farming) at Kecamatan Biringkanaya region are detected over three consecutive years (Table 7).

Table 7. Land use dynamics of Kec. Biringkanaya from 1995-2003 and 2010[11]

Land use	Year - Area (ha)			Year - Differences	
	1995	2003	2010	1995-2003	2003-2010
Urban	243.6	540.0	1003.0	296.4	462.96
Farmland (RF+Dry land)	2492.3	2212.6	1658.4	-279.7	-554.2
wetland	376.7	360.0	451.2	-16.7	91.2

Conversion of agricultural lands in Kecamatan Biringkanaya from 1995 to 2003 (8 years) shows reduction of 279 ha with the rate of 37.06 ha/yr., and between 2003 and 2010 (7 years) the reduction is 554.2 ha or the rate of conversion of 66.14 ha/yr. From these figures implied that the rate of land conversion tends to be increased every year.

Kecamatan Pallangga and Sombaopu (Gowa)

Kecamatan Sombaopu and Pallangga are districts in Kabupaten Gowa and part of

Sungguminasa city. These districts bordering the south and east of the regency, where the farm land of irrigated rice fields and dry land farms are predominant. The urban sprawl on the agricultural land were observed in 14 years (1996-2010). The conversion of the farmlands within this period presented in Table 8, and the converted agricultural fields into urban residential presented in Fig. 3.

Table 8.The change of farmland and urban area of Kec. Sombaopu and Pallangga 1996-2010

Land use	Year		Difference (ha)
	1996 (ha)	2010(ha)	
Agriculture (Ricefield+Dry land Farm)	10.525,7	8.117,39	- 2.408,31
Residential	294,02	2.339,28	+ 2.045,26

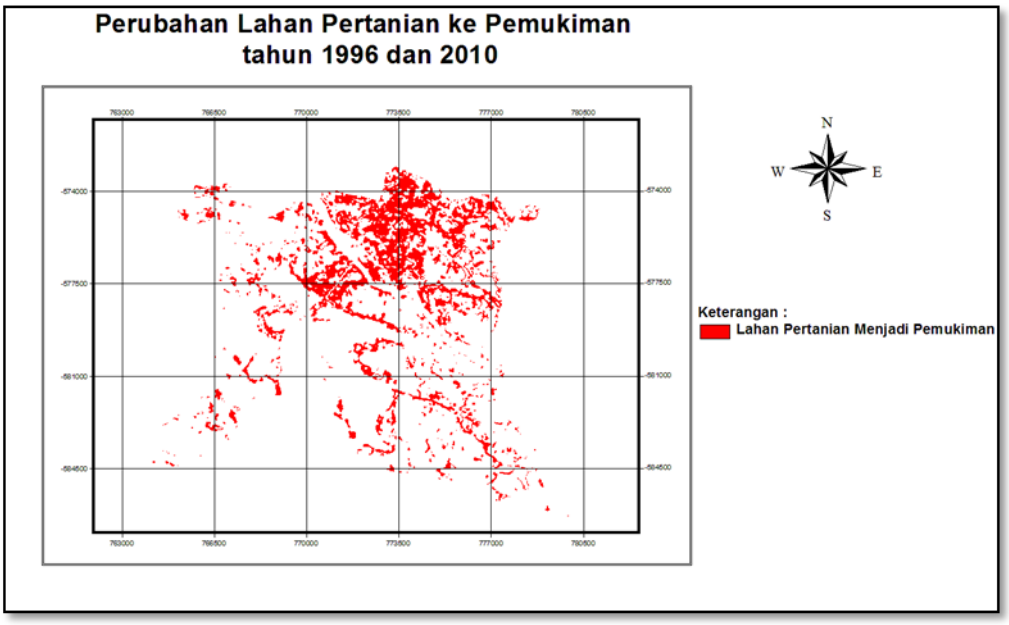

Figure 3. The spatial representation of farmland converted into urban residency of Kec. Sombaopu and Pallangga.

The rate of the farmland in these two districts of Gowa (as shown in Table 8) shows that the agricultural land within 14 years diminished from 10.525 ha to 8.117 ha with conversion rate of 172.02 ha/yr., where the similar increase in urban residential with the same rate.

CONCLUSION

Remote sensing data and GIS tools offers some benefits in observing the rate of land use change include the urban sprawl and dynamic change of agricultural land. The accuracy of classification on farmlands and urban area using supervised classification can be achieved to more than 80 percent both the overall and the Kappa coefficients

The urban sprawl over the vicinity of Makasar and Sungguminasa city and the Jeneberang river delta has been detected. The rate of conversion in Jeneberang delta ranged from 43 to 48 ha/yr., in Kecamatan Biringkanaya from 37 to 66 ha/yr., and in Kecamatan Sombaopu and Pallangga in Sungguminasa city of 172 ha/yr.

REFERENCES

[1] Daniel-Useng, T. Prawitosari, M. Achmad, and Salengke., "Urban Sprawl on Jeneberang Delta of Makassar: A Remote Sensing Perspective," presented at 2nd International Seminar on Sustainable Urban Development (ISOSUD2011), Jakarta, 2011.

[2] R. E. Kennedy, P. A. Townsend, J. E. Gross, W. B. Cohen, P. Bolstad, Y. Q. Wang, and P. Adams, "Remote sensing change detection tools for natural resource managers: Understanding concepts and tradeoffs in the design of landscape monitoring projects," *Remote Sensing of Environment Monitoring Protected Areas*, vol. 113, pp. 1382-1396, 2009.

[3] S. Le Hégarat-Mascle, C. Ottlé, and C. Guérin, "Land cover change detection at coarse spatial scales based on iterative estimation and previous state information," *Remote Sensing of Environment*, vol. 95, pp. 464-479, 2005.

[4] R. S. Lunetta, J. F. Knight, J. Ediriwickrema, J. G. Lyon, and L. D. Worthy, "Land-cover change detection using multi-temporal MODIS NDVI data," *Remote Sensing of Environment*, vol. 105, pp. 142-154, 2006.

[5] M. K. Jat, P. K. Garg, and D. Khare, "Monitoring and modelling of urban sprawl using remote sensing and GIS techniques," *International Journal of Applied Earth Observation and Geoinformation*, vol. 10, pp. 26-43, 2008.

[6] T. M. Lillesand and R. W. Kiefer, *Remote sensing and Image Interpretation*, 3 ed. New York: Joh Wiley & Sons, 1994.

[7] O. R. Abd El-Kawy, J. K. Rød, H. A. Ismail, and A. S. Suliman, "Land use and land cover change detection in the western Nile delta of Egypt using remote sensing data," *Applied Geography*, vol. 31, pp. 483-494, 2011.

[8] L. R. G. Martin and P. J. Howarth, "Change-detection accuracy assessment using SPOT multispectral imagery of the rural-urban fringe," *Remote Sensing of Environment*, vol. 30, pp. 55-66, 1989.

[9] B. Bhatta, *Analysis of Urban Growth and Sprawl from Remote Sensing Data*. London: Springer, 2010.

[10] J. Gao, *Digital Analysis of Remotely Sensed Imagery*. NY: McGraw Hill, 2009.

[11] S. Wero, Daniel-Useng, and P. Totok, "Perambahan kota (Urban Sprawl) di Kota Makassar Berdasarkan Citra Landsat 5 TM (Studi Kasus Kec. Biringkanaya)," in *Keteknikan Pertanian*. Makassar: UNHAS, 2012, pp. 63.

[12] F. Hidayat, Daniel-Useng, and S. Faridah, "Perubahan Lahan Pertanian di Kabupaten Gowa Prov. Sulsel Dengan Menggunakan Citra Satelit Landsat 5 TM," in *Keteknikan Pertanian*. Makassar: UNHAS, 2012, pp. 66.